Design and Diagnostics of a Precise 1-Axis Goniometer Stage for a Kicker Magnet in the Injection Section of the TPS Storage Ring

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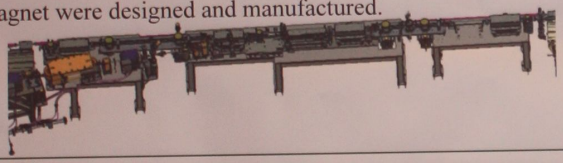
Abstract

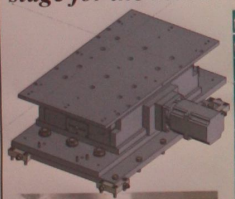
To eliminate the magnitude of vertical magnetic field of the kicker magnet in the injection section of the storage ring in Taiwan Photon Source (TPS), four precise 1-axis goniometer stages for a kicker magnet have been designed and manufactured. In this paper, we present the design and diagnostic process of the goniometer stage, and propose a verification of specification for the stage through the measurement of diagnostic results, including the dimensions, rotary center and resolution. Furthermore, we also construct the relation among a stepping motor, touch sensor and precise inclination sensor obtained through the technique of curve fitting.

Introduction

The electron beam is injected from the end of a transfer line to the injection section of the storage ring. AC/DC septum magnets, four kicker magnets (K1~K4), vacuum chambers and their adjustable stage are mounted on three girders in the injection section, a straight section of length 12 m. To eliminate the magnitude of vertical magnetic field of the kicker magnet in the injection section of the storage ring in TPS, four precise 1-axis goniometer stages for the kicker magnet were designed and manufactured.



Design parameters of a precise 1-axis goniometer stage for the kicker magnet



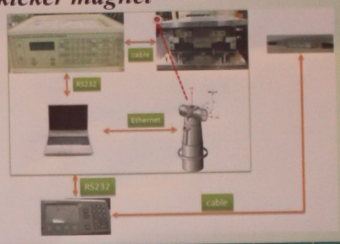
tilt direction	roll
tilt range	±3 mrad
resolution	<0.2 μrad
travel guide	crossed roller V-groove
feeding mechanism	ball screw type
stepping motor	Oriental PK599
gauge to set origin	Heidenhain AT 1218
capacity	>200 kg
limit switch	Omron D4N-2125
the height of rotation center	89.5±0.1 mm
ball screw lead	2 mm
radius of travel guide	187 mm

Limit switches restrict the tilting angle of the stage within ±3 mrad, and interference between the vacuum chamber and magnet can thereby be avoided. A locking mechanism is set in the side of the goniometer stage to fix the movable part when the stage is positioned within tolerance

- The touch sensor (Heidenhain AT 1218) is installed in the other side of the goniometer stage to set the origin and to monitor the tilting angle of the stage.

- Five fine M20 screws serve to adjust the height and pitch of the goniometer stage. Three of these five screws are primary and the others are in auxiliary use to support the stage. Twenty fine nuts are thinned to fit the screws.
- Four L-type blocks in the four corners of the stage serve to adjust the surge, sway and yaw of the stage.

Diagnostics of a precise 1-axis goniometer stage for a kicker magnet



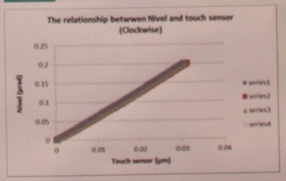
- The rotary center of the goniometer stage is obtained via measurement architecture
- A laser tracker (Leica AT901) serves to measure the moving traces of six fiducial holes when tilting the stage

		stage 1	stage 2	stage 3	stage 4
Front	Height*	89.468	89.4075	-89.4756	89.538
	Error†	-0.032	-0.0925	0.0244	0.038
Middle	Height	89.5687	89.4539	-88.971	89.5144
	Error	0.0687	-0.0461	0.529	0.0144
Rear	Height	89.5803	89.6143	-89.7852	89.6011
	Error	0.0803	0.1143	-0.2852	0.1011

- The error of the RC of stages 1, 2 and 4 (S1, S2 and S4) are almost within 0.1 mm

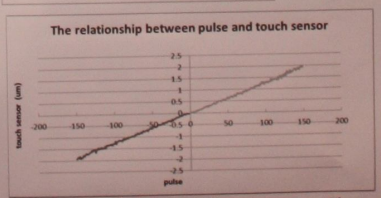
	stage 3	first	second	third	fourth
Front	Height	-89.4756	-89.4163	89.6845	89.4318
	Error	0.0244	0.0837	0.1845	-0.0682
Middle	Height	-88.971	-89.42	89.6145	89.5398
	Error	0.529	0.08	0.1145	0.0398
Rear	Height	-89.7852	-89.9097	89.4759	89.7132
	Error	-0.2852	-0.4097	-0.0241	0.2132

- The results of the RC of stage 3 lack satisfactory accuracy and repeatability



- We use a curve-fitting technique to obtain equation L1 when the stage tilts clockwise

  L1: $\Delta N = 6.5821 * \Delta T$



- The curve relating the pulse (P) and the touch sensor (T) is fitted with the following equation: $\Delta T = 0.0128 * \Delta P$

Theoretical resolution	0.0856
Indirect resolution	0.084

- The good agreement between theoretical and indirect resolution

Conclusions

The design and diagnostic process of a precise 1-axis goniometer stage have been developed. We have also proposed a verification of specification for the stage through the measurement of diagnostic results, including the dimensions, rotary center and resolution. In addition, we further construct the relation among a stepping motor, touch sensor and precise inclination sensor obtained through the technique of curve fitting.

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